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Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

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“Step Out From the Old to the New”

IS 11868 (1987): Constructional requirements of nuclear instruments to afford personal protection against ionizing radiation [LITD 8: Electronic Measuring Instruments, Systems and Accessories]



“ज्ञान से एक नये भारत का निर्माण”

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“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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(Reaffirmed 2006)

*Indian Standard***CONSTRUCTIONAL REQUIREMENTS OF NUCLEAR
INSTRUMENTS TO AFFORD PERSONAL PROTECTION
AGAINST IONIZING RADIATION****(IEC Title : Nuclear Instruments : Constructional Requirements to
Afford Personal Protection Against Ionizing Radiation)****National Foreword**

This Indian Standard, which is identical with IEC Pub 405 (1972) 'Nuclear instruments: Constructional requirements to afford personal protection against ionizing radiation' issued by the International Electrotechnical Commission (IEC) was adopted by the Indian Standards Institution on the recommendation of the Nuclear Instrumentation Sectional Committee and approval of the Electronics and Telecommunication Division Council.

Wherever the words 'International Standard' appear, referring to this standard, they shall be read as 'Indian Standard'.

Cross References

In this Indian Standard, the following International Standards are referred to. Read in their respective place the following:

*International Standard**Corresponding Indian Standard*

IEC Pub 348 (1978) Safety requirements
for electronic measuring apparatus

IS : 9858-1981 Safety requirements for
electronic measuring apparatus

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following IAEA Publication and has decided that it is acceptable for use in conjunction with this standard.

IAEA Pub (1967) Basic safety standards for radiation protection.

Only the English language text of the International Standard has been retained while adopting it in this Indian Standard.

Adopted 28 January 1987

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Gr 5

1. **Scope**

- 1.1 The recommendations apply to electrical measuring instruments incorporating a radioactive *sealed or non-dispersible unsealed source* for self-calibration or for measurement, but excepting instruments used for the control of nuclear reactors or for medical diagnostic or therapeutic purposes.
- 1.2 Recommendations concerning false indications (Clause 8) and ease of decontamination (Clause 9) apply specifically to health physics instruments irrespective of whether the instruments incorporate a radioactive source.
- 1.3 The recommendations do not apply to:
- instruments in which the generation of ionizing radiation by the acceleration of electrons is essential to the measurement function of the instrument, for example X-ray sets;
 - radioactive sources used for measurement but not incorporated in the instruments.
- 1.4 The recommendations concern only personal protection against ionizing radiations, excepting precautions against the hazards of luminising compounds. Recommendations for protection against electric shock, the effects of excessive temperature, explosion and the spread of fire, are given in IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus.
- 1.5 Attention is directed to the existence in most countries of legal requirements and/or codes of good practice governing the possession, use, storage and transport of radioactive sources. Such requirements and/or codes may be more stringent than these recommendations.

Note. — The *useful beam* of some instruments incorporating a radioactive source is hazardous. Protection additional to this recommendation may then be necessary and will depend on the design of the installation.

2. **Object**

To specify intrinsic constructional requirements for those electrical measuring instruments used in connection with ionizing radiation specified in Clause 1 so as to provide reasonable personal protection against ionizing radiation in the use of such instruments, and to specify tests for showing compliance with these requirements.

3. **Definitions**

Sealed source: a source of radioactive materials designed to be used in such a way that the radioactive substance does not enter into immediate contact with the source surroundings. The radioactive materials are either firmly incorporated in solid and inactive materials, or sealed in a capsule of strength sufficient to prevent, under normal conditions of use, any dispersion of radioactive substances and any possibility of contamination including that from the capsule itself.

Non-dispersible unsealed source: a source of radioactive materials which:

- is not a *sealed source*;
- has determinate boundaries;

- is designed so that under normal conditions of use the radioactive materials cannot disperse outside its designed boundaries.

Useful beam: that part of the radiation which comes out of the source and its housing through the aperture, diaphragm, cone or other collimating device.

Protective housing: a housing of a source intended to reduce the *leakage radiation*.

Leakage radiation: all radiation except the *useful beam* coming from within a *protective housing*.

Occupationally exposed person: an adult exposed to ionizing radiation in the course of his work.

Note. — Most countries comply with the recommendations of the ICRP concerning such persons.

Accessible: capable of being touched by either the jointed standard test finger (see Figure 1a, page 18) or the rigid test finger (see Figure 1b, page 18). The finger is applied in every possible position. In case of doubt, the rigid test finger is applied with a maximum force of 30 newtons. The force shall be exerted by the tip of the test finger so as to avoid wedge and lever action. *Accessibility* shall be construed accordingly.

4. General requirements

- 4.1. Incorporated sources shall not be dispersible unsealed sources.
- 4.2. Instruments incorporating sources shall be constructed to ensure, under normal conditions of use, personal protection with respect to:
 - external radiations emanating from the instruments;
 - ingestion hazards;
 - accidental detachment of incorporated sources;
 - the user not being aware of such sources.
- 4.3. Health physics instruments shall also be constructed to ensure, under normal conditions of use, personal protection with respect to:
 - false indications (see Clause 8);
 - ease of decontamination (see Clause 9).

5. Protection requirement categories

For instruments incorporating a source, it is not always possible to obtain radiological protection by constructional means. Four categories of such instruments are therefore recognized according to the restrictive conditions which may be necessary in use.

5.1 Category O — No limitation on use

Instruments containing a radioactive source the activity of which shall not exceed that specified in column 7 of Table IIA of the International Atomic Energy Agency publication, Basic Safety Standards for Radiation Protection, 1967, and around which dose rates shall not exceed:

- one millirem per hour at the exterior surface of the instrument;
- one-tenth of one millirem per hour at 10 cm from the exterior surface of the instrument.

Note. — In some countries, these instruments may be exempt from notification, registration or licensing.

5.2 *Category A – For scientific, commercial or industrial use without restrictive conditions*

Instruments containing a radioactive source the activity of which shall not exceed 1000 times that specified in column 7 of Table IIA of the International Atomic Energy Agency publication, Basic Safety Standards for Radiation Protection, 1967, or 10 millicuries, whichever is the smaller, and around which dose rates shall not exceed:

— 0.75 millirem per hour at a distance of 5 cm from the exterior surface of the instrument.

5.3 *Category B – For use by occupationally exposed persons without restrictive conditions*

Instruments containing a radioactive source the activity of which shall not exceed 10000 times that specified in column 7 of Table IIA of the International Atomic Energy Agency publication, Basic Safety Standards for Radiation Protection, 1967, or 100 millicuries, whichever is the smaller, and around which dose rates shall not exceed:

— 2.5 millirems per hour at a distance of 5 cm from the exterior surface of the instrument.

The source shall not be *accessible*, except:

— when the instrument is in the operative condition,

and if:

— *accessibility* is essential to the functioning of the instrument.

5.4 *Category Z – For use under restrictive conditions imposed nationally or locally for a particular instrument or installation or class of instrument or installation*

Instruments containing a radioactive source, which shall not be *accessible*, except:

— when the instrument is in the operative condition,

and if:

— *accessibility* is essential to the functioning of the instrument.

Category Z is divided into sub-categories Za, Zb, Za/b and Zc.

5.4.1 *Za*

Instruments without shutters but such that the dose rate shall not exceed:

— 20 millirems per hour at a distance of 5 cm from the exterior surface of the instrument,

— 2 millirems per hour at a distance of 1 metre from the incorporated source.

5.4.2 *Zb*

Instruments supplied with a shutter which interrupts the *useful beam*, so made that when the shutter is closed the dose rate shall not exceed:

— 2.5 millirems per hour at a distance of 5 cm from the exterior surface of the instrument.

5.4.3 *Za/b*

Instruments supplied with a shutter and which shall comply with the dose rate requirements of sub-category Za.

5.4.4 *Zc*

Instruments of category Z which do not fall into one of the categories Za, Zb or Za/b.

6. **Mechanical security of incorporated sources**

Instruments shall be constructed so as to guard against the accidental detachment of an incorporated source or part of the source under normal conditions of use.

6.1 Sources shall be *sealed* unless functional requirements make this impracticable. If the source is unsealed, it shall be non-dispersible and the instructions shall call attention to it.

Dispersible unsealed sources are not permitted.

Compliance is checked by inspection, and a certificate from the source manufacturer is required.

- 6.2 An incorporated source shall not be removable except by the use of tools.

Compliance is checked by inspection and a manual test of the fastenings. A force of 30 newtons shall be applied in all possible directions using the rigid standard test finger¹⁾ without causing loosening of the source.

- 6.3 If practicable the source shall be protected against mechanical damage. A shutter, if any, shall not abrade the source.

Compliance is checked by inspection.

7. Marking

- 7.1 To guard against persons not being aware of an incorporated source, instruments shall be marked as follows:

- 7.1.1 Category O instruments need not be marked.

- 7.1.2 Category A, B and Z instruments which incorporate a source shall be marked on the front face with the International Radiation Symbol²⁾ not less than one cm in diameter, together with the chemical symbol and mass number of the source nuclide. Below the symbol, there shall also be marking as follows:

- For Category A: 0.75 mrem/h
- For Category B: 2.5 mrem/h
- For Category Za: 20 mrem/h
- For Category Zb: (the value in mrem/h of the maximum dose rate at a distance of 5 cm from the exterior surface when the shutter is open)/2.5 mrem/h
- For Category Za/b: 20/2.5 mrem/h
- For Category Zc: (the value in mrem/h of the maximum dose rate at a distance of 5 cm from the exterior surface when the shutter, if any, is open) mrem/h.

- 7.1.3 The *protective housing* or surrounding of an incorporated source shall be painted Safety Yellow³⁾ so as to be conspicuous when the instrument is serviced. A label, dimensioned as shown in Figure 2, page 21, shall be affixed close to the source. The label shall display the International Radiation Symbol, the word "Radioactive", the chemical symbol, the mass number and the activity.

- 7.2 *Accessibility* of the source shall be indicated by the words "Accessible Radioactive Source" in the label specified in Sub-clause 7.1.3 above (see Figure 2b, page 21).

- 7.3 If an instrument is fitted with a device to interrupt the useful beam, the control of the device shall indicate its operating state.

Compliance is checked by inspection and measurement of the beam leakage.

- 7.4 In the case of class Z instruments, if practicable, the aperture defining the *useful beam* shall be outlined in Safety Red³⁾.

Compliance is checked by inspection.

¹⁾ See Figure 1b, page 18.

²⁾ Defined by ISO Recommendation R 361-1963.

³⁾ Colour defined by ISO Recommendation R 408-1964.

8. False indications by health physics instruments

8.1 Overload conditions

Instruments for measuring:

- X and gamma exposure;
- X and gamma exposure rate;
- neutron fluence;
- neutron fluence rate,

whilst presented to radiation greater than the nominal full scale value¹⁾ shall so indicate by remaining out of scale at the higher end. Additionally, X and gamma exposure meters and neutron fluence measuring instruments shall remain out of scale on removal from the radiation.

For instruments with switchable scale ranges²⁾, the requirement shall apply on each range.

Compliance is checked:

- 8.1.1 For exposure meters whose nominal full scale value is less than 800 R, by irradiation for 10 minutes by gamma or X radiation having an exposure rate such that the exposure in this period is not less than 100 times the nominal full scale value, or an exposure rate of 10^4 R/h, whichever is the lesser.

For exposure meters whose nominal full scale value is not less than 800 R, by irradiation to twice the nominal full scale value at a rate not less than 10^4 R/h³⁾.

There shall be an evident indication of overload within a period of twice the time for the full scale exposure to be received and this indication must persist for at least one hour after cessation of the irradiation.

- 8.1.2 For exposure rate meters, by irradiation for a period of 2 minutes at an exposure rate of not less than 100 times the nominal full scale value or 10^4 R/h, whichever is the lesser.

There shall be an evident indication within 5 seconds that the instrument is reading out of scale at the higher end and this indication must persist until the irradiation ceases.

Note. — Instrument circuitry may, due to a scale-of-two dividing effect, sometimes cause a spurious fall-back indication not detected by the foregoing tests. Compliance should therefore be checked by presenting the instrument to a steadily increasing field rising to at least 10 times the nominal full scale value at a rate not exceeding the factor «e» (2.718, the base of natural logarithms) in a period equal to the time constant of the instrument.

- 8.1.3 For neutron fluence measuring instruments, by irradiation for a period of 10 minutes by a fluence of neutron energy within the stated response range of the instrument and of such rate that the fluence in this period is not less than 100 times the nominal full scale value.

There shall be an evident indication of overload within a period of twice the time for the full scale fluence to be received and this indication must persist for at least one hour after cessation of the irradiation.

- 8.1.4 For neutron fluence rate measuring instruments, by irradiation for a period of 2 minutes to a fluence of neutron energy within the stated response range of the instrument and of a fluence rate between two and three times the nominal full scale value.

¹⁾ If such instruments, especially high-sensitivity instruments, cannot sustain overload without damage, they shall be marked by the manufacturer with the limiting value of exposure, exposure rate, neutron fluence or neutron fluence rate up to which they are immune (see ICRU - Report 20, 1971).

²⁾ Alternatively, these instruments may be provided with automatic upwards range switching operable by overload, with an evident indication.

³⁾ The exposure rate and duration to be agreed upon by manufacturer and user.

There shall be an evident indication within one minute that the meter is reading out of scale at the higher end and this indication must persist until the irradiation ceases.

Note. – For instruments indicating in rems, the equivalent fluence should be in accordance with the current recommendations of the International Commission on Radiological Protection*.

8.2 *Pulsed fields*

In pulsed fields of ionizing or radio frequency radiation, for example from linear accelerators, certain instruments may be sensitive to the periodicity of the pulses. It is sometimes impracticable to construct an instrument to be entirely immune. Users must therefore make operational checks, such as switching the pulsed field on and off and observing the behaviour of the instrument over its whole sensitivity range when brought into the field from a distance.

Any known characteristics of an instrument with respect to pulsed fields should be stated in the user's handbook.

9. **Ease of decontamination of health physics instruments**

Portable instruments for the measurement of exposure and exposure rate, alpha and beta radiations, neutron fluence or neutron dose, and radioactive contamination shall be constructed so as to facilitate decontamination.

These instruments shall comply with one or more of the following three sub-clauses.

9.1 *Decontaminable exterior surface*

The instruments shall have an easily decontaminable exterior surface, for example, a smooth non-porous surface-free from crevices.

Compliance is checked, unless otherwise specified in special recommendations, as follows:

On a typical spot of the surface of the instrument, put a drop of a solution of a radioactive isotope of short half-life and of energy not less than 500 keV, for example, sodium 24 or lanthanum 140; the activity to be 0.5 microcurie on drying. After decontamination without abrasives, the background noise of the instrument must remain unchanged and a smear give not more than 100 disintegrations/minute.

9.2 *Easily replaceable windows*

The instruments shall have easily replaceable windows.

Compliance is checked by inspection. It is permissible for an instrument to have an easily replaceable window covering a display or control panel in combination with a smooth non-porous surface elsewhere.

9.3 *Use in protective cover*

The instruments shall be usable when placed inside a thin flexible disposable or easily decontaminable cover fitted with transparencies to permit reading of the instrument scales. For instruments fitted with a probe and its connecting cable, it shall be permissible to put only the probe into a protective cover, provided the instrument itself is easily decontaminable.

Compliance is checked by practical demonstration.

*ICRP-Publication 4, 1962, revised 1963. To be published: Supplement to Publication 15, 1969.

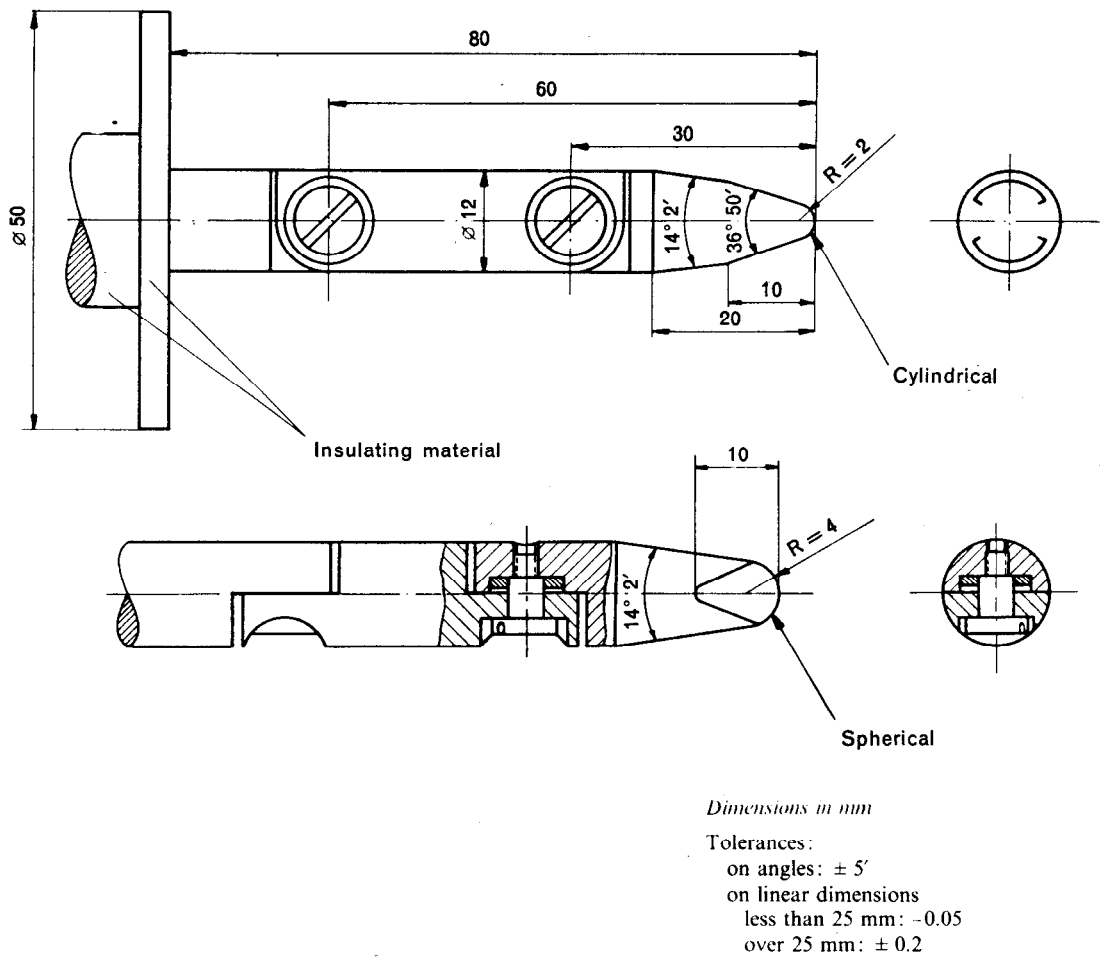


FIG. 1 a Jointed standard test finger. Ref.: Clause 3.

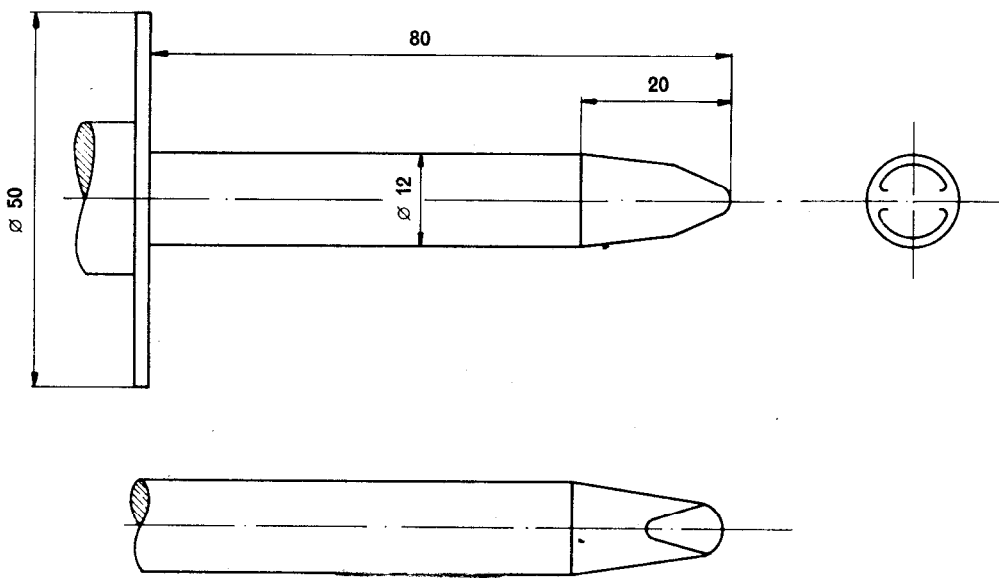


FIG. 1 b Rigid test finger. Ref.: Clause 3 and Sub-clause 6.2.

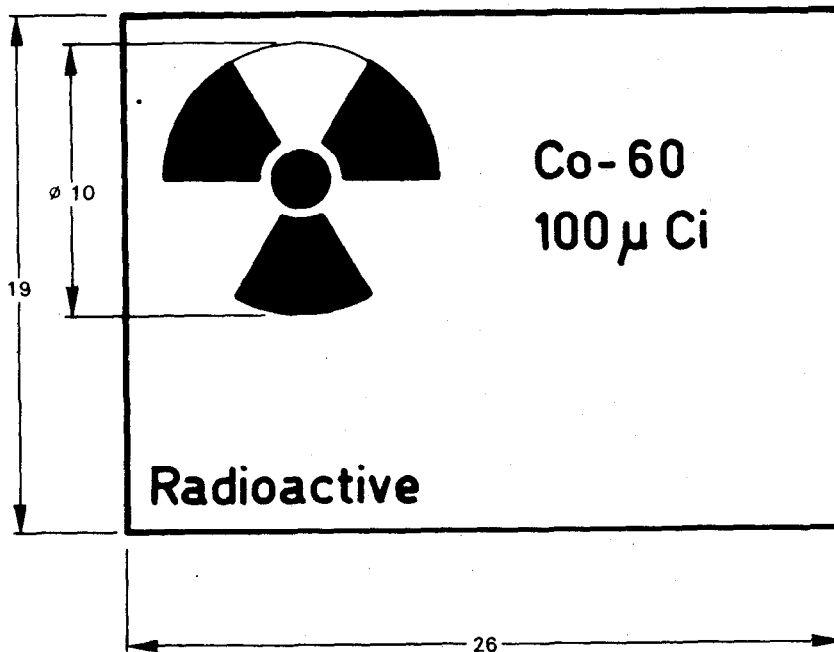


FIG. 2a) – Example of label to indicate an incorporated radioactive source.
Ref.: Sub-clause 7.1.3.
Minimum dimensions as shown, larger sizes to be proportionate.

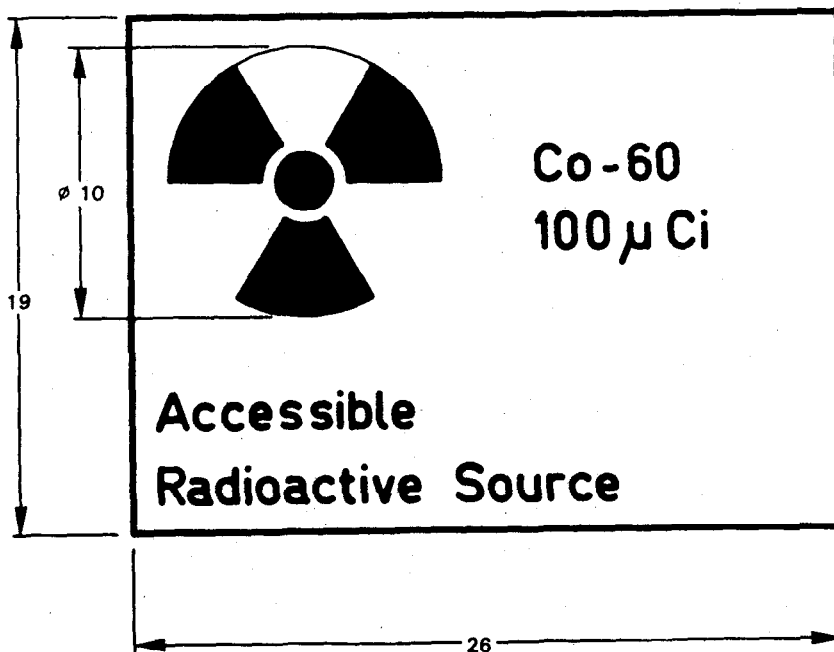


FIG. 2b) – Example of label to indicate an incorporated accessible radioactive source.
Ref.: Sub-clause 7.2.

Dimensions in mm